

would mean a tussle with aileron and rudder to keep on an even keel; but that once their snowy summits were passed the fight would end and that the big bombers would glide on their way as if on a glassy sea. Exceptions to this rule were unusual enough to draw out a good deal of comment when they occurred. An excellent example of such an exception was found on the afternoon raid of August 29, 1918.

Two raids were made on that day, one in the morning and another in the afternoon. In the morning, although thunderheads were forming and we had the customary bumpy weather until they were surmounted, the usual placidity was found above. The clouds had increased by afternoon and it was so rough that only four planes out of the original 10 that started remained in the air, the others turning back before they had climbed a thousand meters. The remaining four stuck together, thinking to get through the clouds to the calm above, and the appearance of another escadrille overhead, which we joined a few minutes afterwards, encouraged us in this idea.

It is pretty work getting a formation through the clouds, requiring much twisting and turning to rise through the holes to the blue above, judgment on the part of the leader, who must guard against sharp turns or running into a cloud, and vigilance on the part of the pilots, who must keep their position and avoid collision, while being tossed about relentlessly in the upward surging and restless air.

Expectation of finding smooth sailing in the upper air, however, was not realized on this occasion. Although the region of cloud was left far below—so far that the once imposing masses of mountainous white had lost their individuality and seemed merged in a sea of petty billows—we were still encountering undulatory currents and of so marked a nature that in my notes on the raid, set down immediately afterwards, I have referred to them as bumps. In winter we might have expected overlapping currents and consequent roughness at any altitude, but to find them in midsummer and at 5,000 meters was extraordinary, and in my personal experience distinctly worthy of note. My meteorological training naturally led me to look for some development which would visibly attest the extra-local character of what was going on, so I was not surprised when cirrus clouds began to appear overhead in what had been a sky of unobstructed blue. Before the lines were reached we were sailing between two cloud strata,—a rapidly thickening cirro-stratus veil above, cumulus and strato-cumulus beneath.

The weather map for this date did not reveal any marked cyclonic developments. The barometer was high in western Europe and relatively low over the Baltic regions. The map for August 30, however, the day after our raid, bore evidence of a different character. It showed a fall in pressure over northwestern Europe and indicated the approach of a disturbance to the north of Scotland, an augury confirmed by the chart of August 31, which depicted a typical depression central in the North Sea and causing unsettled, rainy weather throughout the British Isles, the Netherlands, and northern France.

When the group moved eastward in September to take part in the Meuse operations of the 1st American Army, opportunity was afforded of doing cross-country work over a very different type of land. It was much more hilly; in fact, there was so little level or cleared ground that airdrome sites in the region around Bar le Duc, where many squadrons were clustered, were difficult to find. Flying over such a country, if it was at all wind

swept, gave a pilot plenty of work to do at low elevations, especially if he were flying one of the larger types of plane. The greatest uncertainties, of course, were involved in landing. Coming to earth at express-train speed is a matter of nicety even with everything in one's favor, but to do it day in and day out on fields remarkable only for their unevenness and limited extent gives one ample familiarity with the fickleness of surface currents when distorted by irregularities of the terrain.

The plane may be almost seated, wheels and tail skid about to brush the earth, when a puff catches the ship and lifts it into the air again or tilts it sidewise, calling for the quickest action from the pilot to avert a stripped undercarriage or a scraped wing. Sometimes the only thing to do is to put on the motor and circle the field for another landing.

As regards the consideration of safety, no danger is to be feared from air bumps so long as the pilot enjoys sufficient altitude in which to maneuver. He may be tossed about and even thrown into a slip, but, given enough space and a properly lined-up ship, he can recover himself and maintain flight even under the most boisterous conditions of wind and weather. His difficulties await him as he approaches the earth. For this reason rolling ground never should be chosen for a permanent landing field. The necessities of war require the use of whatever flying fields can be found; but in the case of civilian flying, the selection of such fields should be a matter of the most careful judgment, so that the danger of accident from the principal uncertainty of present day aviation may be reduced to the minimum.

DISCUSSION.

The condition of bumpiness above, as well as below, cumulus clouds in the forward part of a cyclone may be explained as follows:

The southerly wind of the front of a cyclone rides under the upper portions of the remains of the westerly or northwesterly wind which the southerly wind has displaced at the lower levels. This upper wind is likely to be cold, whereas the lower, southerly wind is likely to be warm. During the first day that the southerly wind blows the continued fall in temperature of the upper current and the rise in temperature of the lower one frequently produces a temperature gradient which exceeds the adiabatic, and thus establishes convection between the two winds. As the difference in temperature increases, the depth of the convective layer of adjustment increases until its under boundary may reach the top of the layer of surface local convection marked by cumulus clouds. In the case described, the upper convective layer does not seem quite to have reached the lower one; if it had, the cumulus clouds would have extended rapidly to the top of the upper convective layer and gone beyond.

Mr. J. C. Edgerton, in his fully kept meteorological logs of his daily postal mail flights from Washington to Philadelphia and return in the summer of 1918, mentions several times the occurrence of "bumpy weather" in the lower levels and at intermediate levels in the morning, but very bumpy conditions from the ground to great heights in the afternoon.

When alto-cumulus clouds are visible when a southerly wind is blowing at the surface, they probably mark the top of the higher bumpy layer, just as the cumuli summits mark the top of the lower.—*Charles F. Brooks.*